

Mini-Review

Catalysts for Stone Age innovations

What might have triggered two short-lived bursts of technological and behavioral innovation in southern Africa during the Middle Stone Age?

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Fossil and genetic evidence suggests the emergence of anatomically modern humans (*Homo sapiens*) in sub-Saharan Africa some time between 200 and 100 thousand years (ka) ago. But the first traces of symbolic behavior—a trait unique to our species—are not found until many tens of millennia later, and include items such as engraved ochres and eggshells, tools made from bone, and personal ornaments made of shell beads. These behavioral indicators appear in concert with two innovative phases of Middle Stone Age technology, known as the Still Bay (SB) and Howieson's Poort (HP) industries, across a range of climatic and ecological zones in southern Africa. The SB and HP have recently been dated to about 72–71 ka and 65–60 ka, respectively, at sufficiently high resolution to investigate the possible causes and effects. A remarkable feature of these two industries is the spatial synchronicity of their start and end dates at archaeological sites spread across a region of two million square kilometers. What were the catalysts for the SB and HP, and what were the consequences? Both industries flourished at a time when tropical Africa had just entered a period of wetter and more stable conditions, and populations of hunter-gatherers were expanding rapidly throughout sub-Saharan Africa before contracting into geographically and genetically isolated communities. The SB and HP also immediately preceded the likely exit time of modern humans from Africa into southern Asia and across to Australia, which marked the beginning of the worldwide dispersal of our species. In this paper, we argue that environmental factors alone are insufficient to explain these two bursts of technological and behavioral innovation. Instead, we propose that the formation of social networks across southern Africa during periods of population expansion, and the disintegration of these networks during periods of population contraction, can explain the abrupt appearance and disappearance of the SB and HP, as well as the hiatus between them. But it will take improved chronologies for the key demographic events to determine if the emergence of innovative

technology and symbolic behavior provided the stimulus for the expansion of hunter-gatherer populations (and their subsequent global dispersal), or if these Middle Stone Age innovations came into existence only after populations had expanded and geographically extensive social networks had developed.

Africa is widely regarded as the continent of origin of modern humans (*Homo sapiens*), with the earliest anatomical remains dating to almost 200 thousand years (ka) ago in Ethiopia.¹ But the first evidence for symbolic items and personal ornaments is much more recent, dating to around 100–70 ka ago at sites in Israel,² Morocco³ and South Africa.^{4,5} Many possible causes have been advanced for this apparently delayed emergence of symbolic behavior, including the invention of language,⁶ a genetic mutation⁷ or rapid environmental changes.⁸ Archaeological sites spread across two million km² of southern Africa offer potential insights into the mechanisms involved in the process of us 'becoming human'. Here, symbolic items such as engraved ochres^{4,9} and ostrich eggshells,¹⁰ shell beads^{5,11} and bone points¹² have been found in association with two phases of enhanced sophistication in the technology of stone tool manufacture, known as the Still Bay (SB) and Howieson's Poort (HP) industries. Among the SB toolkit are bifacially flaked points that probably formed parts of spearheads,¹³ whereas the HP industry includes blade-like tools that were blunted ('backed') on one side and hafted as part of composite weapons.¹⁴ Recent archaeological excavations have revealed that the SB preceded the HP,^{10,13} and that both are sandwiched between (and possibly separated by) less sophisticated Middle Stone Age (MSA) artifacts. A diverse range of opinions exists on why these two industries appeared suddenly and then vanished soon after, but distinguishing between the competing theories has been thwarted by inadequate chronologies. Recently, we completed a study that resolved the timing of the SB and HP industries with much improved accuracy and precision,^{15,16} thereby providing the opportunity to look afresh at the question of what may have triggered these two bursts of technological and behavioral innovation, which immediately preceded the initial exodus of modern humans out of Africa.^{17–21} In this paper, we speculate on these matters, taking into account recent genetic reconstructions of the demographic history of early modern human populations within Africa and the contemporaneous environmental conditions and climatic events experienced by these communities of hunter-gatherers.

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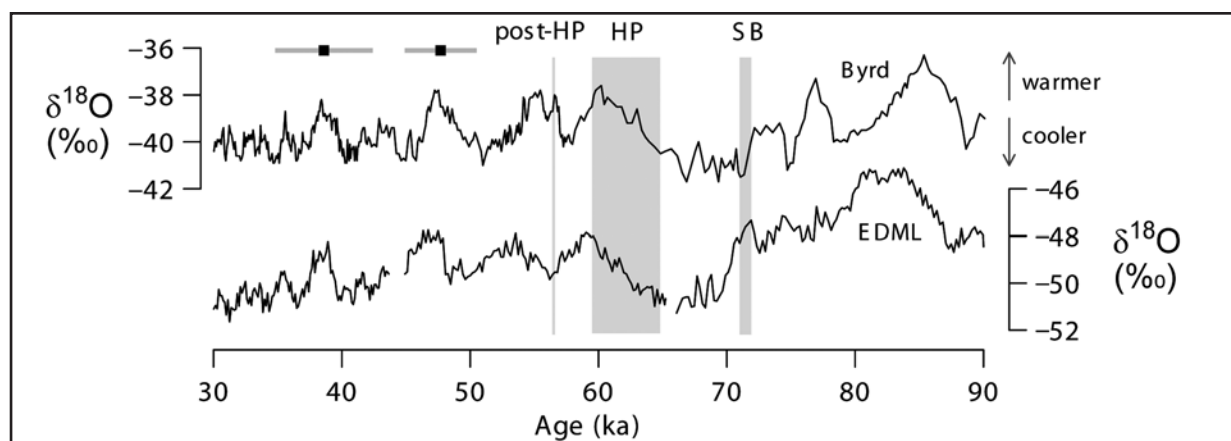


Figure 1. Oxygen isotope data (expressed in per mil) for the period 90–30 ka obtained from the Byrd²⁶ and EPICA Dronning Maud Land (EDML)²⁴ ice cores from West and East Antarctica, respectively. The vertical grey bands delineate the start and end dates, and durations, of the SB and HP industries and the timing of the immediately post-HP pulse.^{15,16} The solid black squares and horizontal grey bars denote the mean ages and 95% confidence intervals for the late and final MSA periods.²²

In our earlier study,^{15,16} we found that the SB lasted no longer than perhaps 1,000 years (from about 71.9 to 71.0 ka), and was then separated by an interval of several thousand years from the start of the HP, about 64.8 ka ago. Five millennia later, at about 59.5 ka, the HP ended abruptly, with the first of the subsequent periods of less sophisticated MSA technology (the ‘post-HP’) beginning at about 56.5 ka. There appears to have been no spatial patterning in the timing of the SB and HP across geographic or climatic boundaries: each began and ended essentially instantaneously across southern Africa, at sites located along the coastline of South Africa, in mountainous Lesotho, and in semi-arid Namibia. Because the timing cross-cuts a diverse range of climatic and ecological zones, we infer that local or regional climatic conditions could not have been the driving force behind these bursts of technological and behavioral innovation. On the other hand, we do not discount the important influence that climatic factors likely exerted on whether rock shelters were occupied or abandoned by modern humans during these periods.²² Given the lifestyle of hunter-gatherers, preferred sites of habitation and resource exploitation must have been determined, to some extent at least, by the prevailing local environmental conditions.

There is a further reason to challenge the view that the SB and HP, and their associated symbolic items, can be explained simply as technological and behavioral responses to environmental change. Over the relevant part of the last glacial cycle, southern Africa experienced marked climatic fluctuations associated with global changes in ice volume, sea level, and patterns of oceanographic and atmospheric circulation, as recorded in ice cores from West and East Antarctica.^{23–26} The HP occurred during a period of climatic warming (regardless of which Antarctic ice-core record is chosen for comparison), whereas the SB is not clearly associated with any such warming trend (Fig. 1). Moreover, two subsequent MSA periods of less sophisticated technology, known as the ‘late’ and ‘final’ MSA,²² and possibly the ‘post-HP’ pulse,¹⁵ also occurred during warm intervals, yet none of these periods is notable for technological or behavioral innovation. Hence, when the issue of possible environmental forcing of archaeological events is viewed in broad perspective for the period between 80 and 40 ka, we cannot identify

any specific climatic attribute that is exclusively associated with the SB and HP industries.

What, then, might have triggered the onset and termination of these two periods of technological and behavioral creativity? The answer may lie in the demographic histories of hunter-gatherer populations, as has been recently reconstructed from mitochondrial DNA (mtDNA) and Y chromosome studies of living humans. A genetic legacy of ancient population bottlenecks, expansions and isolations, occurring at about the same time as the SB and HP industries, is emerging for sub-Saharan Africa.^{27–31} The importance of these results in the present context is two-fold. First, the most recent of these studies³¹ has revealed that the effective population size of one of the four major indigenous African mtDNA haplogroups (L3) increased rapidly between 80 and 40 ka, and that this haplogroup is also the only one with descendants outside of Africa. Studies of sediment cores from lakes in tropical Africa, the favored source region for the first modern humans to exit the continent, indicate temperature and precipitation variations over this time interval,^{32,33} including the onset of generally wetter and more stable conditions at about 70 ka.³² But the fact that haplogroups L0, L1 and L2 do not show similar population expansions at the same time as L3 can be interpreted as an independent line of evidence against environmental change being the sole catalyst for human dispersals within and out of Africa—if this were the case, then all four haplogroups should show similar demographic trends.³¹

The second important finding of recent genetic studies is the identification of periods of population isolation, as well as expansion, in sub-Saharan African populations over the time span of interest.^{28–30} These indications are consistent with an ancient origin for click languages, which are currently spoken in southern and eastern Africa by populations that last shared a common ancestor more than 35 ka ago, implying their genetic and geographic separation since that time.²⁸ Similarly, a large number of evolutionarily successful mtDNA lineages (more than 40) are thought to have existed in southern and eastern Africa during the period in which the SB and HP flourished,³⁰ which lends additional support to the notional presence of geographically isolated hunter-gatherer communities throughout

sub-Saharan Africa. The combination of population expansions and subsequent contractions, occurring more than once, may provide an explanation for the spatially synchronous appearance and subsequent disappearance of the SB, and later the HP, at a sub-continental scale, as well as for the temporal gap between these two industries. The SB may reflect an episode of population expansion of the L3 haplogroup in southern Africa, during which social networks promoted the rapid transmission of this advance in technological sophistication and florescence of symbolic behavior throughout the region. This suite of behavioral changes may have bestowed a competitive advantage on hunter-gatherer communities, perhaps by promoting group coordination and cohesion³¹ or by enhancing technological efficiency and economic productivity.⁸ The end of the SB represents the disintegration of this social network, owing to population contractions and isolations, perhaps induced by the cooler climate that prevailed between 71 and 65 ka (Fig. 1). Cultural innovations are less likely to survive or prosper among small and solitary social groups.³⁴ Connections were not re-established until the start of the HP, five millennia later, when local populations again expanded, but this time in association with a different technological innovation (backed blades). The demise of the HP reflects the final collapse of this integrated, sub-continental network of hunter-gatherer communities, and their return to a number of geographically isolated and genetically distinct populations. Similarly sophisticated stone-tool technology did not reappear until the advent of the Later Stone Age, about 40 ka ago, when there is evidence for renewed genetic admixture in the sub-Saharan mtDNA pool.^{29,30}

The issue of modern human behavior and dispersal integrates the fields of archaeology, genetics, linguistics, ecology and climate science. A unifying theme is the need for reliable age control, placed on a common, numerical timescale. The new ages for the SB and HP in southern Africa^{15,16} need to be matched by similarly accurate and precise chronologies for the key environmental changes and demographic events in sub-Saharan Africa. Only then will it be feasible to discern clearly the timing of these archaeological industries with respect to population expansions and contractions, and any contemporaneous shifts in climate. With an improved timeframe, it may be possible to assess the likelihood that the emergence of innovative technology and symbolic behavior provided the initial stimulus for population expansions within Africa—and the subsequent exodus of people out of Africa—or, alternatively, that demographic growth, perhaps triggered by local climatic events, was the catalyst of modern human ingenuity and creativity.

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